examiner's comments, applicant respectfully requests in paragraph (2) above, **cancellation of all previous claims, 1 though 26, and substitution of new claims 27 through 53, incorporating examiners comments, as explained below**.

Paragraph (4) In further respectful accordance with examiner's comments of page 8, paragraph 1, under "Allowable Subject Matter," applicant has **redrafted the canceled dependent claims 10 and 21 as independent claims, incorporating all the limitations of Claim 1** (comprising the substance of the base claim and any intervening claims). The newly re-written claims are numbered as claims 27 and 28, respectively. Applicant's intent in drafting new claims 27 and 28 is to render them immediately allowable in accordance with examiner's comments with respect to the canceled claims 10 and 21. Claim 29 is also written after that manner, but differently phrased. Should these claims not be deemed allowable, applicant respectfully requests constructive assistance in order to place them in allowable condition as soon as possible and without need for further proceedings. Telephone or fax contact is welcome.

Paragraph (5) **New dependent claims 30-35, 37-48, and 50-56 incorporate all the subject matter of new independent claim 27** and **add additional subject matter**, comprising the substance of canceled claims 1-6, 8-9, 11-20, and 22-26. Additionally, **new claim independent claim 27 is drafted in the examiner proposed allowable form** per examiner's helpful comments, discussed in *paragraph (4)*, above. Therefore **claims 30-56 are respectfully submitted as, now, a fortiori and independently, patentable over the references.**

Paragraph (6) In respectful response to examiner's comments with respect to claim 7, (see examiner's pg 2, line 1) applicant requests in *paragraph (2)*, above, cancellation of claim 7 without substitution. However, with respect to claim 8 fuel injection comprises a valid embodiment of the applicant's technology and is included in new claim 35.

Paragraph (7) In addition to the above and in respectful clarification of an apparently **misunderstood reference**, the applicant offers that examiner appears to have **misunderstood** the art of Warren (6209495). The apparent mistake is that, contrary to the examiner's comments on page 3, lines 10-12, regarding claim 12, Warren teaches no oil cooling, nor a sump acting as a heat sink. Referring to the Warren application, column 15, lines 40-44, 50-53, and 55-57, and column 21, lines 18-20, we note that, in fact, no oil returns from the pistons to the sump, at all. (See Enclosure (4).) The Warren art pumps oil to the piston rings, to comprise a thin lubrication layer dispersed on the cylinder walls, none of which returns to the sump. Segregated sump-to-piston-to-sump oil circulation and return as taught by the instant applicant, is, so far as any reference has been able to establish, novel to the applicant's art. Most certainly,

the voluminous piston-to-sump cooling oil recirculation provisions, sufficient to dissipate significant heat, are unique to the instant applicants teaching.

Paragraph (8) With respect to examiner listed-but-not-relied-upon reference, US Patent 2,825,319, by Harrer. Applicant respectfully concurs that it has little applicability. Close examination reveals that the art taught therein has little in common with the applicant's art, beyond a vague physical resemblance. Harrer teaches, as does the instant applicant, a piston engine having a piston rod with a piston at each end. At this point, the resemblance ends, for the Harrer patent is directed toward a combination combustion engine and compressor, so configured as to directly apply reciprocating motion of internal combustion engine pistons to separate, reciprocating compressor pump pistons, bypassing the usual translation of reciprocating drive piston motion into rotary motion or single direction linier motion. There is, in fact, no motion translation at all, but virtually direct transmission of the reciprocal motion of the drive pistons to the compressor pistons. The claims, bearing this out, and in contrast to the instant application, are directed only at, and universally require, integral, but separate, parallel, compressor component pistons, in addition to the drive pistons.

CONCLUSION

Paragraph (9) For all of the above reasons, and in view of the above amendments and clarifications, the applicant submits that his specification and claims are now in proper form, and that the claims all define art patentable over previous technologies. Therefore, the applicant submits that this application is now in condition for allowance, which action he respectfully solicits.

Paragraph (10) If, for any reason, this application is not believed to be in full condition for allowance, the applicant respectfully requests the constructive assistance and suggestions of the examiner pursuant to M.P.E.P. § 2173.02 and § 707.07(j) in order that the undersigned can place this application in allowable condition as soon as possible and without the need for further proceedings.

Paragraph (11) *Because all previous claims are, herein, requested canceled, no "marked-up" claims list is enclosed.*

Very respectfully,

David Douglas Winters

David Douglas Winters
USPTO reg.# 50,746

Encl:
(1) App. 1: Copy of USPTO letter confirmation. no.3705 mailed 07/05/2005
(2) App. 2: Claims List, Clean Copy, annotated with status
(3) App. 3: Excerpts from patent application of Warren, 6,209,495 B1

CERTIFICATE OF MAILING: I certify that on the date below, this document and referenced attachments will be deposited with the EXPRESS MAIL US POSTAL SERVICE on the date indicated, addressed to: "BOX NON-FEE AMENDMENTS, PO Box 1450Alexandria, VA 22313-1450, USA.

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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
10/700,255	11/03/2003	Freddie Ray Roberts	030403ROBERTS	3705

7590 07/05/2005

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EXAMINER	
HARRIS, KATRINA B	

ART UNIT	PAPER NUMBER
3747	

DATE MAILED: 07/05/2005

Please find below and/or attached an Office communication concerning this application or proceeding.

APP 1

Office Action Summary	Application No.	Applicant(s)	
	10/700,255	ROBERTS, FREDDIE RAY	
	Examiner	Art Unit	
	Katrina B. Harris	3747	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If the period for reply specified above is less than thirty (30) days, a reply within the statutory minimum of thirty (30) days will be considered timely.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on *07 January 2005*.

2a)☐ This action is **FINAL**. 2b)☒ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4)☒ Claim(s) *1-26* is/are pending in the application.

4a) Of the above claim(s) *7 and 8* is/are withdrawn from consideration.

5)☐ Claim(s) _____ is/are allowed.

6)☒ Claim(s) *1-6,9,11-20 and 22-26* is/are rejected.

7)☒ Claim(s) *10,18 and 21* is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

9)☐ The specification is objected to by the Examiner.

10)☐ The drawing(s) filed on _____ is/are: a)☐ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

11)☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

12)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☐ All b)☐ Some * c)☐ None of:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☒ Notice of References Cited (PTO-892)
2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
3) ☐ Information Disclosure Statement(s) (PTO-1449 or PTO/SB/08) Paper No(s)/Mail Date _____.
4) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____.
5) ☐ Notice of Informal Patent Application (PTO-152)
6) ☐ Other: _____.

App. 1

DETAILED ACTION

Election/Restrictions

Claims 7 and 8 withdrawn from further consideration pursuant to 37 CFR 1.142(b), as being drawn to a nonelected invention, there being no allowable generic or linking claim. Applicant timely traversed the restriction (election) requirement in the reply filed on January 7, 2005.

The traverse is moot since no claims would be exclusive to species (II). Applicant will be held to election of claims exclusive to species (II) are later presented.

Claim Rejections - 35 USC § 102

The following is a quotation of the appropriate paragraphs of 35 U.S.C. 102 that form the basis for the rejections under this section made in this Office action:

> A person shall be entitled to a patent unless –
>
> (b) the invention was patented or described in a printed publication in this or a foreign country or in public use or on sale in this country, more than one year prior to the date of application for patent in the United States.

Claims 1-6, 9, 11-20, 22-26 are rejected under 35 U.S.C. 102(b) as being anticipated by Warren (6,209,495). Warren discloses an internal combustion engine machine incorporating significant improvements in power, efficiency and emissions control comprising, a one or more cylinders, each having a head, a combustion chamber, a base, a compression chamber and a sidewall, One or more means of igniting fuel in the cylinders; One or more sources of intake air; a means of storing and/or cooling lubricating oil between cycles of circulation, A drive train, a means of encasing, protecting, cooling and lubricating the drive train; A means of segregating the

oil in the sump and/or crankcase from the air or air/fuel mixture in the cylinder, A means of dispersing oil on the cylinder walls and of then gathering excess for return to the oil sump; A means of transmitting energy to and from the pistons, a means of guiding each piston rod such that it moves in a linear manner, always along the same line; a means of drawing air or air/fuel mixture into the engine machine, propelling it into the cylinder combustion chamber, compressing it for ignition and propelling its expulsion afterr ignition; a means of admitting air and fuel, or air/fuel mixture into each cylinder; a means of efficiently expelling exhaust gases resulting from combustion of the air fuel mixture after energy has been extracted; a means of transmitting energy from the piston rod to the drive train; a means of cooling the engine; a means of transporting dispersing gathering and returning lubricating/cooling oil while keeping it segregated from combustion air and fuel;

Regarding claim 2, comprising a plurality of cylinders in one or more banks of two opposing cylinders each;

Regarding claim 3, wherein the means of transmitting energy to and from the each piston is a piston-rod with a piston attached at one end, each piston rod passing through the base of its cylinder, carrying the force of its associated piston power stroke to the drive train, the piston rod be linked to the drive shaft by a push rod in the crankcase/oil sump, propelling a transmission mechanism, such as a crank-plate or other rotary or linier device powering a drive shaft;

Regarding claim 4, an engine machine as in claim 1 wherein the means of cooling the engine is via exhaust gas expansion, cooling fins on the engine machine

and via a large volume of oil circulated through the cylinders and pooled in the sump, the sump acting as a heat sink for oil circulating from the cylinders',

Regarding claim 5, wherein the means of transmitting energy from the piston rod to the drive train is a rotary deice, such as a crank plate, linked to the piston rod by a push rod;

Regarding claim 6, in which the means of transmitting energy from the 15 piston rod to the drive train is, such as a rack and pinion transmisssion system, segmented gear drive, or a ratchet device;

Regarding claim 9, wherein the means of admitting air or air/fuel mixture into each cylinder obtained by intake pods in the sidewall of each cylinder',

Regarding claim 11, wherein the means of drawing air or air/fuel mixture into the system, propelling it into the cylinder combustion chamber, compressing it for ignition and expelling it after ignition is a "multi-function piston' that draws air or air/fuel mixture from the intake source and into the compression chamber beneath the piston on an up stroke and propels it out of the compression chamber into the cylinder combustion chamber above the piston on a down stroke, and on the immediately subsequent upstroke, compresses the air or air/fuel mixture in the combustion chamber, then, upon combustion and expels the exhaust;

Regarding claim 12, wherein the means of guiding each piston rod such that it moves in a linear manner, always along the same line is the compression wall and the piston rod compression seal serving as a piston rod guide to hold each pistons in correct position within its cylinder;

Regarding claim 13, wherein there is provided for each cylinder, a multi-function piston performing four "drive" functions plus lubrication, the "drive" functions being to (1) draw in new air or air/fuel mixture into the intake chamber (2) propel the new air or air/fuel mixture into the combustion chamber (3) compress the 26 air/fuel mixture in the cylinder combustion chamber, (4) receive the force of combustion for the power stroke for transmission to the piston rod, and (5) receive, disperse and recoup lubricating oil for return to the oil sump/cooler;

Regarding claim 14, wherein the means of dispersing oil on the cylinder walls and of then gathering excess for return to the oil sump is oil hoarding rings, these rings located near the head and base of each piston, such that they contain any oil dispersed between them, and when in motion, push said oil before them, substantially wiping it off the cylinder walls and leaving only a fine film behind as they move

Regarding claim 15, wherein the means of segregating the oil in the sump and/or crank case from the air or air/fuel mixture in the cylinder is in the form of a compression wall and piston rod pressure seal at the base of each cylinder, the compression wall segregating the fuel and air in the cylinder from the lubricating/cooling oil in the oil sump/crankcase, thus creating a segregated and sealed intake chamber into which the air or fuel/air mixture is first received from the carburetor or breather and from which it is discharged into the cylinder combustion chamber, the piston rod passing through the compression wall at the base of each corresponding cylinder and into the sump/crankcase by way of the compression wall and pressure seal;

Regarding claim 16, wherein the means of encasing, protecting, and lubricating the drive train is a combination crankcase/oil sump;

Regarding claim 17, wherein the means of storing and/or cooling the oil between cycles of circulation is a combination crankcase/oil sump;

Regarding claim 19, wherein the means of igniting the fuel is an electrical spark;

Regarding claim 20, wherein, the means of transporting, dispersing, gathering and returning lubricating/cooling oil while keeping it segregated from combustion air and fuel is a dynamic force lubricating oil pump comprising a piston rod/lubrication assembly that serves as both a means of transmitting force to and from the piston and as a means to transmit lubricating/cooling oil to its cylinder via a multi-function piston, the assembly comprising a piston rod with a multi-function piston attached to each end and oil pick-up and exhaust pods in its mid section, and oil transport passages in the piston rod from the oil pick-up nozzles to the multi-function piston assembly and back to the oil exhaust ports, the piston assembly having a multi-function piston configured with one or more radially situated oil inlet and outlet ports that distribute lubricating oil to the associated cylinder and recovers the oil for return to the sump/crankcase, using oil hoarding rings near each piston head and base to assist in dispersing and then re-gathering the oil for return to the cooling sump such that oil flows through the piston rod and piston, and around the piston, lubricating and cooling piston walls, piston rings and cylinder walls, and returns through the piston and piston rod to the oil sump/crank case for cooling, the piston rod and drive train being lubricated by splash distribution in the crank-case/oil sump;

Regarding claim 22, wherein a wrist pin links each piston to its piston rod, rendering the combination less rigid;

Regarding claim 23, wherein the means of igniting fuel in the cylinders comprises explosive compression in the cylinder head;

Regarding claim 24, wherein means of igniting fuel in the cylinders comprises a glow plug.

Regarding claim 25, wherein the means of transmitting energy to and from the pistons is a piston-rod between and joining each pair of pistons in each cylinder bank such that each piston rod has a piston at each end, the piston rod passing through the bases of each associated cylinder, each piston rod carrying the force of each piston power stroke to the drive train, and across to the opposite associated piston to power that piston's compression stroke, the piston rod to be linked to the drive shaft: by a push rod in the crankcase/oil sump, propelling a crank-plate or other rotary or linier transmission device that is geared to the drive shaft;

Regarding claim 26, wherein there is a plurality of banks of cylinders, each bank comprised of two or more cylinders and the drive train of each bank joined to the drive train of its neighboring bank(s) in such a way that each bank may be independently disconnected from its neighbor(s) and shut down automatically or at the discretion of the operator, the manner of joining the bank drive trains being, in example, manual clutcht(es), centrifugal clutcht(es), or ratchet devices.

Allowable Subject Matter

Claims 10 and 21 are objected to as being dependent upon a rejected base claim, but would be allowable if rewritten in independent form including all of the limitations of the base claim and any intervening claims.

Conclusion

The prior art made of record and not relied upon is considered pertinent to applicant's disclosure. U.S. Patent No. 2,825,319 issued to Harrer is a similar system.

Communication

Any inquiry concerning this communication or earlier communications from the examiner should be directed to Katrina B. Harris whose telephone number is 571-272-4842. The examiner can normally be reached on 6:30 AM -3:00 PM.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Henry Yuen can be reached on 571-272-4856. The fax phone number for the organization where this application or proceeding is assigned is 703-872-9306.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free).

Katrina B. Harris
Examiner
Art Unit 3747

KBH

Andrew M. Dolinar
Primary Examiner

App. 1

Notice of References Cited

Application/Control No.	Applicant(s)/Patent Under Reexamination	
10/700,255	ROBERTS, FREDDIE RAY.	
Examiner	Art Unit	Page 1 of 1
Katrina B. Harris	3747	

U.S. PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Name	Classification
	A	US-2,825,319	03-1958	HARRER HERBERT W	123/46A
	B	US-6,209,495	04-2001	Warren, Walter	123/55.2
	C	US-			
	D	US-			
	E	US-			
	F	US-			
	G	US-			
	H	US-			
	I	US-			
	J	US-			
	K	US-			
	L	US-			
	M	US-			

FOREIGN PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Country	Name	Classification
	N					
	O					
	P					
	Q					
	R					
	S					
	T					

NON-PATENT DOCUMENTS

*		Include as applicable: Author, Title Date, Publisher, Edition or Volume, Pertinent Pages)
	U	
	V	
	W	
	X	

\ copy of this reference is not being furnished with this Office action. (See MPEP § 707.05(a).)
ates in MM-YYYY format are publication dates. Classifications may be US or foreign.

122*a* and 122*b* remain properly aligned with the respective connecting rods.

Provisions designed into the spherical connector mechanism **64**, FIG. **4**, in conjunction with provisions in the connecting rods and pistons, serve to direct lubricating oil to the piston rings. In the spherical connector mechanism, these provisions consist of lube oil channel **122**, FIG. **10** and drillings **122***a* and **122***b*. Input crank **104**, FIG. **11** of the epicyclic gear crank assembly **3** is rotatably constrained in spherical bearing **118** by means of needle roller bearing assembly **109**, the outer circumference of which is a press fit in spherical bearing **118**. Lube oil is fed to the needle roller bearing assembly via drilling **112** in the input crank arm **104** of the epicyclic gear crank assembly to lubricate needle rollers **110**. The housing **111** of needle roller bearing asembly **109** is capped at one end and is sealed at the other end by means of seal **109***a*. Drillings **111***a* around the circumference of the needle bearing housing permits lube oil to pass out of the needle roller bearing assembly via drillings **111***a*, channel **122**, and drillings **122***a* and **122***b* to miniature one-way valves **123** and **123***a* at the bottom end of the connecting rods **63** and **63***a*.

Referring to FIG. **11**, since both left and right hand pistons are identical, only the right hand piston, connecting rod and lube oil path will be described in detail. A drilling **124** in connecting rod **63***a* connects the output of miniature one-way valve **123** mounted at an inner end with the input of a second one-way valve **123***a* mounted within an outer end of the connecting rod. Cutout channels **128** at the top of the connecting rod serve to permit the lubricating oil to pass into drillings **127** in piston **38***a*. Drillings **127** extend radially outward from the connecting rod such that the outer end of each drilling is spaced towards the gear crank assembly **3** in relation to the inner end of the drilling. Typically, three such drillings **127** would be used in each piston equally spaced to evenly distribute the lube oil around the piston. An orifice plug **126** in each drilling serves to restrict the lube oil flow to the annular groove which carries the upper piston ring **125**.

During operation, the piston and connecting rod undergo high negative acceleration forces during the upper half of the cycle near the top dead center position. This causes lubricating oil to gradually migrate through the two one-way valves **123** and **123***a* towards the piston. But since the slope on lube oil channels **127** is negative, there is a tendency for any lube oil in channels **127** to flow back towards the upper one-way valve. However, one-way valve **123***a* blocks any such flow. On the bottom half of the cycle near the bottom dead center position, the piston is under high acceleration in the opposite direction, and these forces then tend to cause the lube oil to be forced out through the orifice plugs **126** to fill the piston ring channel. And since the piston ring is also under the same forces of acceleration as the piston, the lube oil is squeezed into the piston ring groove on the upper side. As the piston subsequently moves up the cylinder towards the top dead center position, a film of lubricating oil is deposited on the cylinder walls.

Turning next to FIG. **4**, left and right scavenge valves **48** and **48***a* are connected to the outer ends of the respective cylinders **24** and **24***a*. The left and right scavenge valves **48** and **48***a* are opened and closed by means of left and right rocker arms **53** and **53***a*, left and right push/pull rods **54** and **54***a* and common valve operating mechanism **67**. Referring to the left-hand cylinder head, when scavenge valve **48** is opened, supercharged scavenge air enters the cylinder via air intake passage **52**, through pre-combustion chamber **50**, and into combustion chamber **51**. The scavenge air entering the cylinder forces the expended exhaust gases out of the cylinder via the exhaust ports **39**. The timing of the scavenge valve is such that it closes at approximately the same time that piston **38** covers exhaust ports **39** as it starts back up the cylinder. Thus at the point that the exhaust ports are covered and the scavenge air flow stops, all spent exhaust gases will have been swept out of the cylinder, and replaced with clean, unspent air. With the exception that the fuel/air intake is via the front of the cylinder head instead of via the bottom, as is the case for the scavenge air flow, the fuel/air intake and the scavenge intake valve trains are substantially identical.

The arrangement of the fuel/air intake valve details versus the scavenge air intake valve are shown in detail in FIG. **12**. FIG. **12** illustrates the fuel/air and scavenge intake valve arrangement connected to the outer end of the left hand cylinder; however, the arrangement of the fuel/air and scavenge air intake for the right hand cylinder is essentially the same. As shown in FIG. **12**, the thoroughly atomized fuel/air mixture enters the cylinder head via intake passage **52**, thence through open fuel/air intake valve **137** and into lefthand pre-combustion chamber **50**, whence it is ignited by spark plug **26**. The scavenge and fuel/air intake valves **48** and **137** are constrained in two dimensions by respective valve guides **138** and **138***a* and are mechanically opened and closed by means of respective valve adjuster barrels **139** and **139***a*, via respective slider bushings **140** and **140***a* and respective forks **141**/**141***a* and **141***b*/**141***c* which are integral with the respective rocker arms **53**. This fork and slider bushing arrangement simply allows the rotary arc motion of the rocker arms to be converted to straight reciprocating action for opening and closing of the valves.

The scavenge and fuel/air intake valve linkages are completely enclosed by means of valve linkage housings **56** and **56***a*, FIG. **4** which are physically constrained adjacent respective left and right cylinder heads and camshaft housing **68**. The valve linkage housings are bolted to camshaft housing **68** and are sealed to prohibit oil leakage. Access plates **55** and **55***a* serve to gain access for valve adjustment purposes and are similarly oil sealed. Both the camshaft and valve linkages operate in a partial oil bath, and drillings **68***a* and **68***b* serve to permit lubricating oil to enter the valve linkage housing, whence the valves are lubricated by means of splash action caused by the rocker arms.

Referring again to FIG. **4**, and particularly the right hand cylinder; this figure shows the right hand piston **38***a* at top dead centre at the point where combustion occurs. When the piston is at top dead centre, combustion chamber **51***a* is at its smallest volume, and is bounded by the face of piston **38***a* and the internal surface of cylinder head **25***a*. This chamber is interconnected to precombustion chamber **50***a* via the waisted portion **57***a*. Because the opening and closing of the fuel/air intake valve lags behind that of the scavenge valve, there is a gradation in the fuel/air mixture within the combustion chamber, with an enriched fuel/air mixture in chamber **50***a* and virtually clean air only in chamber **51***a*. This arrangement permits the carburetion or fuel injection to operate at a very lean mixture, and still have an enriched fuel mixture adjacent to the spark plugs **26** and **26***a*, respectively.

In the valve train as shown in FIG. **4**, the cam-actuated valve operating mechanism **67** serves to both open and close the valves rather than relying on a cam linkage to open the valves and springs to close them. The valve operating linkage is shown in an enlarged cross-sectional view in FIG. **14**. The centrally positioned cam shaft **85** is spanned by mating cam followers **133** and **134** that are constrained vertically and axially by means of machined channels **86** and **87** shown in FIG. **5** in camshaft housing **68** and matching

APP. 3

nents from the cylinders. With this oil seal between the main housing and the lower portion of the cylinder, it is less likely that lubricating oil will be lost via the exhaust manifold to atmosphere - thus reducing this source of possible emissions.

Since the lower portion of the cylinder is not splash lubricated as is typical in four-stroke engines, and since for environmental reasons it is not desirable to mix the lubricating oil with the fuel as is done in typical two-stroke engines, some means is included to provide lubricating oil to the piston rings. Because the high piston-to-cylinder side forces have been eliminated, there is not as great a need for cylinder wall lubrication as there is in conventional two and four-stroke engines; nonetheless, some lubricant is still required to lubricate the piston rings. This is achieved by the use of a forced flow lubrication channel through the drillings in the connecting rods and piston, which lead to the piston ring seals. This provision allows a very small but measured amount of lubricant to be deposited on the cylinder wall ahead of the piston rings on each piston up stroke.

The spent exhaust gases are completely purged from the cylinder by a separate scavenge air flow before the fuel/air mixture enters the cylinder. Further, the intake timing is such that the intake valve does not open until after the exhaust ports at the bottom of the cylinder are closed by the piston as it begins its up stroke. This provision completely eliminates the problem of unburned fuel being lost to exhaust. However, it also necessitates the use of two separate, valve trains and intake air flows—one for scavenge air and one for the fuel charged air. Further, the scavenge valve is located in the cylinder head so that, as the spent exhaust gases exit through the exhaust ports at the bottom of the cylinder, they are completely swept out by the surge of scavenge air entering at the top.

Because an epicyclic gear crank replaces the conventional crankshaft, the crankcase cannot be used to pre-compress the fuel air mixture as is done in a conventional two-stroke engine. Instead, a dual element, direct drive supercharger is used so that two completely separate air flows can be achieved - one flow to scavenge the exhaust gases from the cylinder and one to inject a well-atomized fuel/air mixture into the cylinder, timed such that it only enters the cylinder after the piston has started its up stroke and the exhaust ports are closed. While conventional carburetion could be used, a special rotary-type fuel injector is deployed. The rotary-type fuel injector is designed to spray variable amounts of fuel into the air flow up-stream of the supercharger and into the fuel/air intake portion of the supercharger only. Separate manifolds carry the scavenge and intake air flows to the cylinder heads, and each intake flow is controlled via separate timed valves.

The fuel-charged air is injected into a pre-combustion chamber in the cylinder head that is separated somewhat from the combustion chamber proper, formed between the upper portion of the piston and the cylinder head. This precombustion chamber incorporates both the scavenge and fuel/air intake valves, as well as the spark plug. What these two separate but interconnected combustion chambers accomplish is to allow an enriched air/fuel mixture to be injected into the pre-combustion chamber after the piston has started its up stroke and which essentially remains in the pre-combustive chamber adjacent to the spark plug. Because the scavenge air valve is open for that portion of the cycle during which the exhaust ports are uncovered, it serves not only to propel the spent gases out of the cylinder, but also leaves the cylinder filled with clean air. It is this residual scavenge air that is subsequently compressed on the piston up stroke, and which remains in the chamber between the piston and cylinder head. This arrangement, whereby the fuel-charged air is injected separately from the scavenge air after the piston has started its up stroke, results in a highly enriched volume of air in close proximity to the spark plug, but with only a very small amount of fuel in the piston/cylinder head cavity. This concentrated fuel/air mixture in the pre-combustion chamber, coupled with nearly pure air in the piston/cylinder head cavity will result in a very lean-burning engine, yet one not prone to back-firing which might otherwise result from an excessively lean fuel/air mixture.

The requirement of having a positive means for closing the valves is achieved by using an opening cam for each scavenge and fuel/air intake valve spanned on either side by identical closing cams. Two specially designed cam followers, each having an opening 'heel' and two closing 'fingers' span the cams, one on the top and one on the bottom. This cam follower arrangement permits a single opening and closing cam array to operate the related scavenge and fuel/air intake valves for both horizontally opposed cylinders.

In order to meet the objective of easy disassembly, as well as to permit the camshaft to operate in an oil bath, the cam housing is made as a separate assembly, which simply bolts onto the bottom of the main housing containing the epicyclic gear crank unit. Since the cylinder head is a modified L-shape type, the valve linkage can be very short, which is highly desirable for operation at the higher RPM required of this camshaft.

While the pistons and connecting rods are much lighter than in a conventional engine, there is still some requirement for counterbalancing, particularly since both opposing pistons operate in sync. This is achieved by using two relatively small counter-rotating weights, one attached to the rotating body portion of the epicyclic gear crank, and the other being a separately driven weight which is bearing-mounted on the main body housing, and being roughly the same distance forward of the piston-to-piston center line as the epicyclic gear crank mounted weight is to the rear. The front counterweight is driven via gears from the camshaft such that it turns at the same RPM as the epicyclic gear crank mounted counterweight but in the opposite direction. This arrangement results in a nearly complete dynamic balance, both in the horizontal piston-to-piston axis, as well as along the vertical axis.

Because the main body housing for the epicyclic gear crank is continuously supplied with recirculating oil, some small amount of oil will gradually seep out past the connecting rod seals. As well, there will inevitably be some blowby of air and oil past the piston rings on each compression stroke. To ensure that even this small amount of airborne oil is prevented from flowing to exhaust, a poppet type exhaust valve is used. A vent line is connected from the lower portion of the cylinders (at the crossover channel) to the intake side of the fuel/air supercharger section. This means that any small quantity of seepage oil, from either source, will be mixed with the fuel/air intake mixture and will be burnt. These provisions will result in a very clean burning engine that will bear very little resemblance to the conventional two-stroke engine in the amount of emissions produced.

Because direct conversion from reciprocating to rotary motion is achieved without the use of a conventional crankshaft, this means that the frictional losses caused by the high piston-to-cylinder sidewall forces, which are highest during the mid-point of the combustion cycle, are com-